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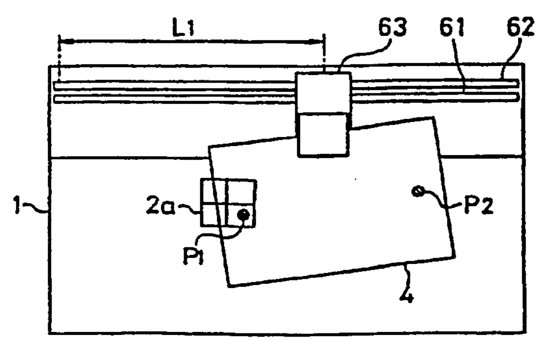
Online :WPI

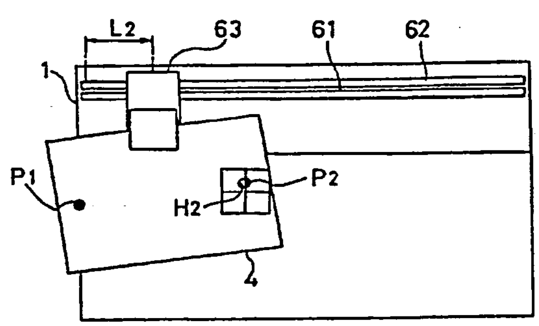
(54) Method and apparatus for perforating printed circuit boards

(57) A chuck member 63 for chucking and moving a printed circuit board 4 on a work table 1 and a linear scale 62 are provided. One of two reference marks P1 preliminarily attached on one side of the printed circuit board 4 is imaged with imaging means e.g. an X-ray camera or TV camera, to obtain the position data of the central position of the mark. The location of the chuck 63 on the linear scale is recorded at this time. Then the printed circuit board 4 is manually moved so that the other reference mark P2 enters an imaging area and the position data of its central position is obtained. At this time, the position data of the chuck member 63 is detected with the linear scale 62. Then the distance between the centres of both reference marks is determined on the basis of the position data of the central positions of both reference marks obtained by image processing and the positional data of the linear scale. The predetermined distance between the perforations is compared with the distance between the centres of the marks that has been obtained from the aforementioned calculation thereby obtaining the error between the two distances. The error is preferably divided into halves to be equally shared between the position data of the central positions of the reference marks to determine the positions for perforation where the perforation is performed with the perforating means. (see fig 9 for flowchart).

F I G. 10



F I G. 11



GB 2 288 229 A

FIG.1

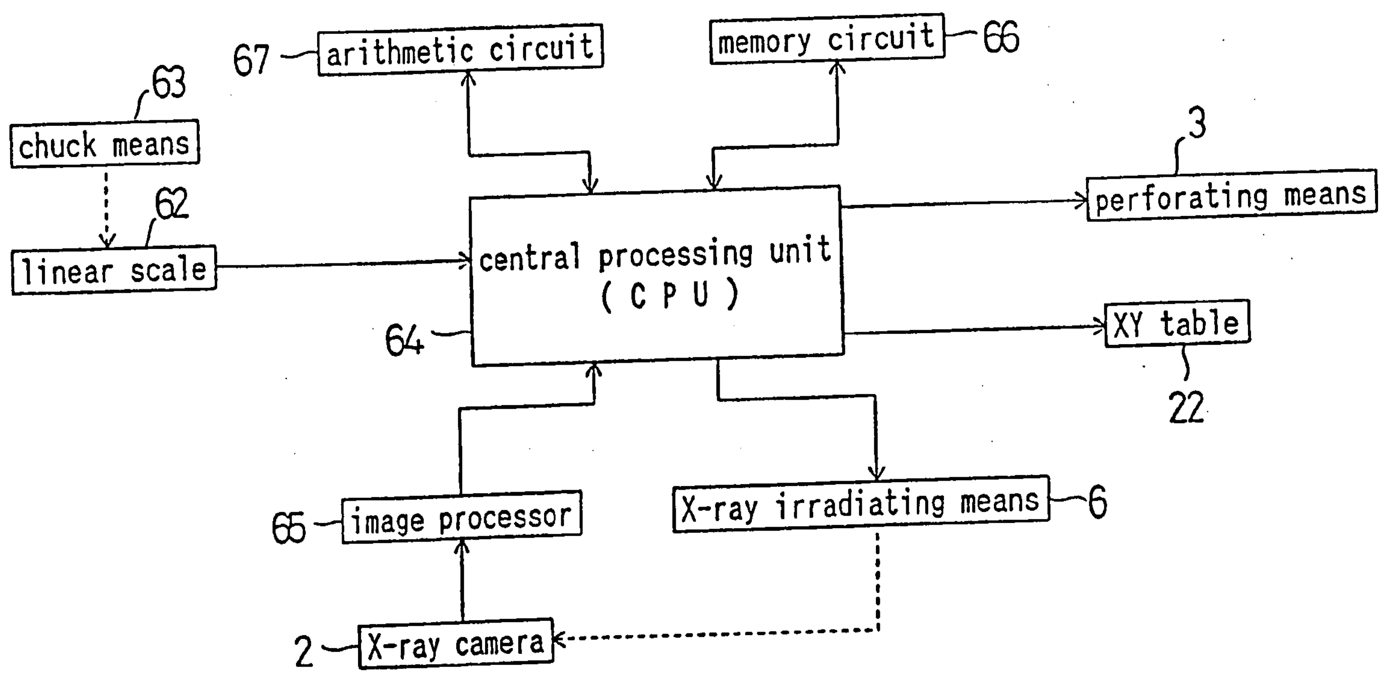

chuck means
63
linear scale
62
67
arithmetic circuit
memory circuit
66
central processing unit
(C P U)
64
perforating means
3
XY table
22
image processor
65
X-ray irradiating means
6
X-ray camera
2

FIG. 2

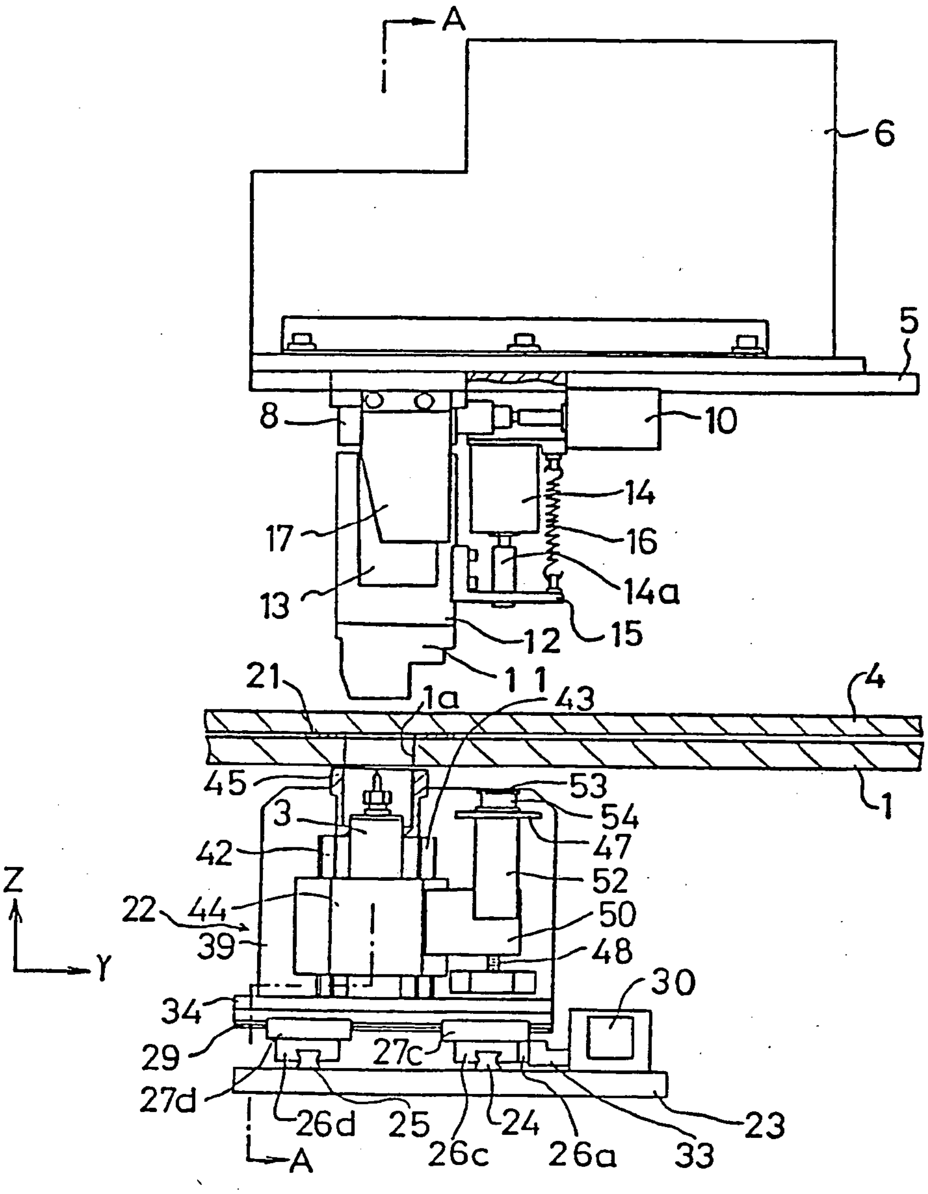

A
6
5
8
10
14
17
16
14a
13
15
12
11
21
1a
43
4
45
53
1
3
54
42
47
52
22
44
50
39
48
Z
Y
34
30
29
27c
27d
26d
25
24
26a
23
26c
33
A

FIG. 3

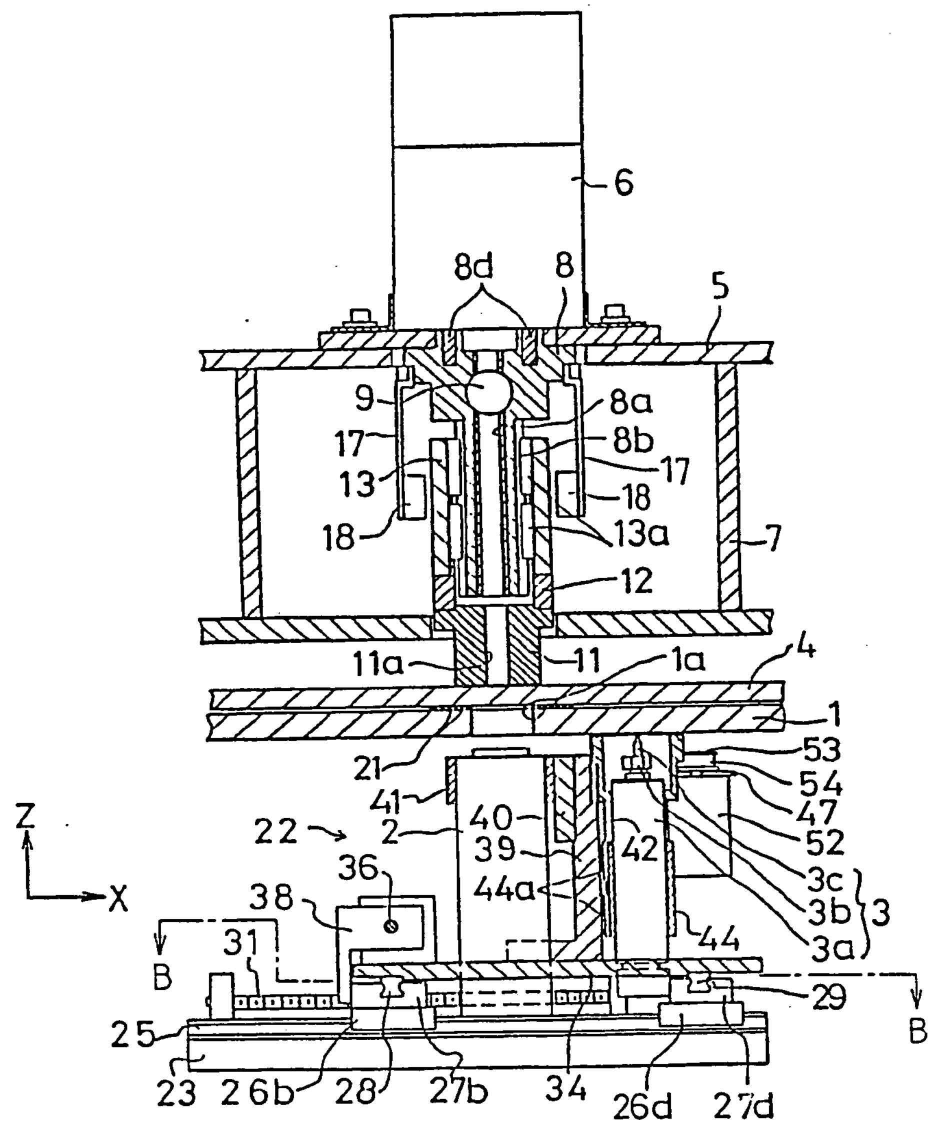

6
8d
8
5
9
8a
17
8b
13
17
18
18
13a
7
12
11a
11
1a
4
1
21
53
54
41
40
47
22
2
52
Z
X
39
42
3c
36
44a
3b
3
38
3a
44
B
31
29
B
25
23
26b
28
27b
34
26d
27d

FIG.4

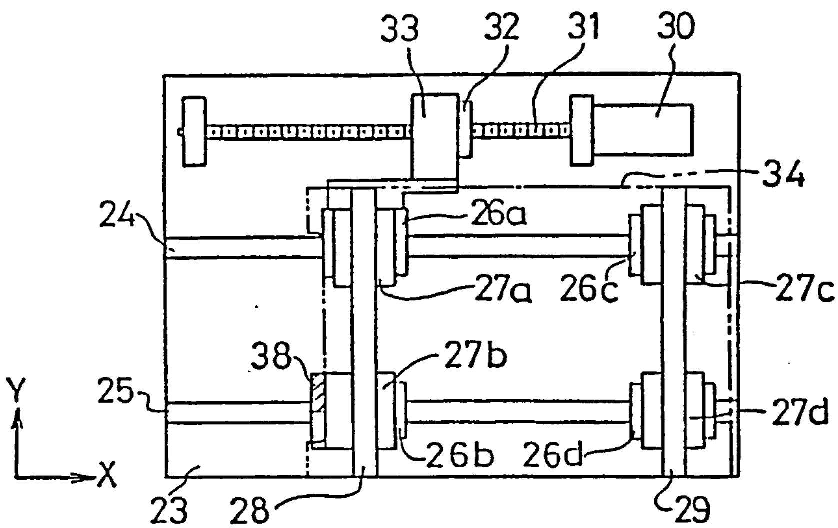
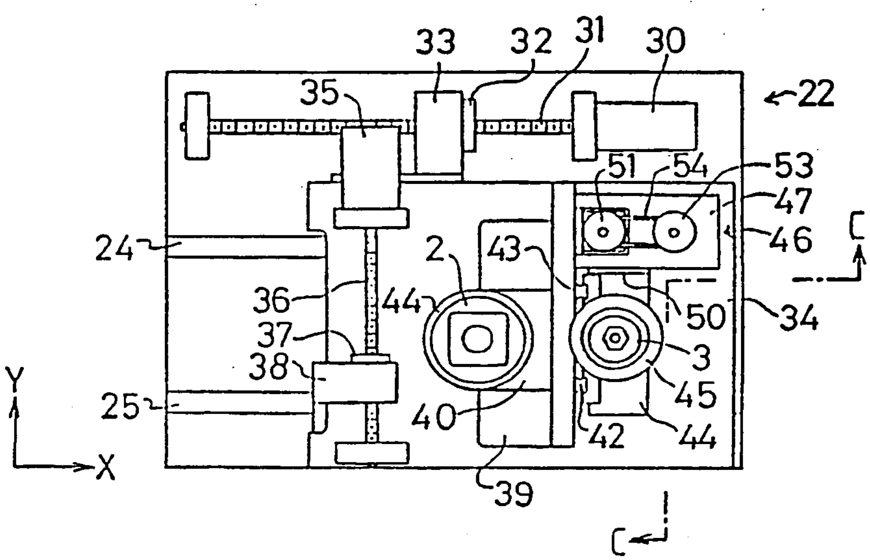
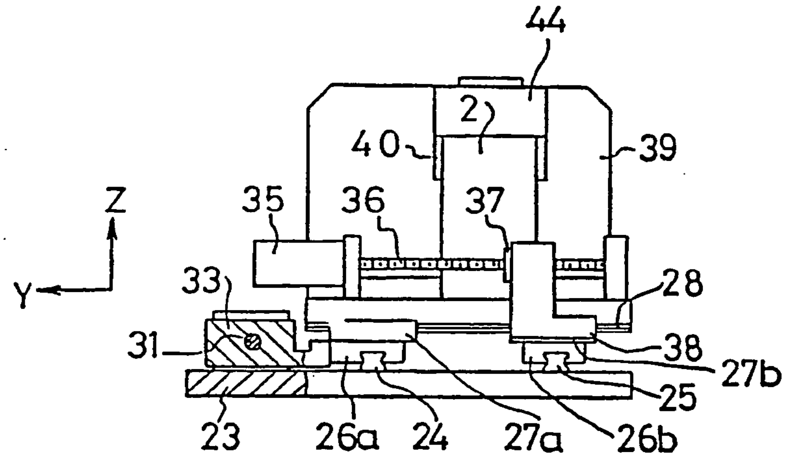

33
32
31
30
34
24
26a
27a
26c
27c
38
27b
25
27d
26b
26d
Y
X
23
28
29

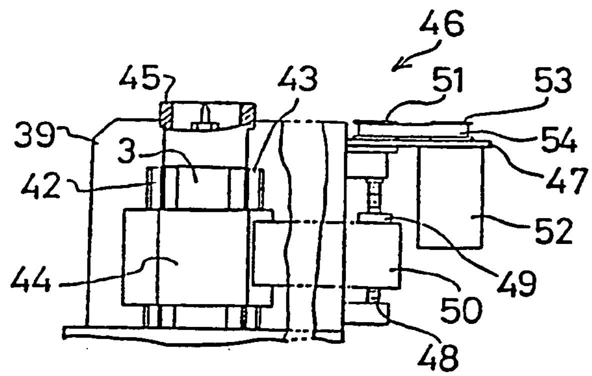
FIG.5


33
32
31
30
22
35
51
54
53
47
46
24
2
43
36
44
50
34
37
3
38
45
Y
25
40
42
44
X
39

F I G. 6


44
2
40
39
Z
35
36
37
Y
33
28
31
38
27b
25
23
26a
24
27a
26b

F I G. 7


46
45
43
51
53
39
3
54
42
47
52
49
44
50
48

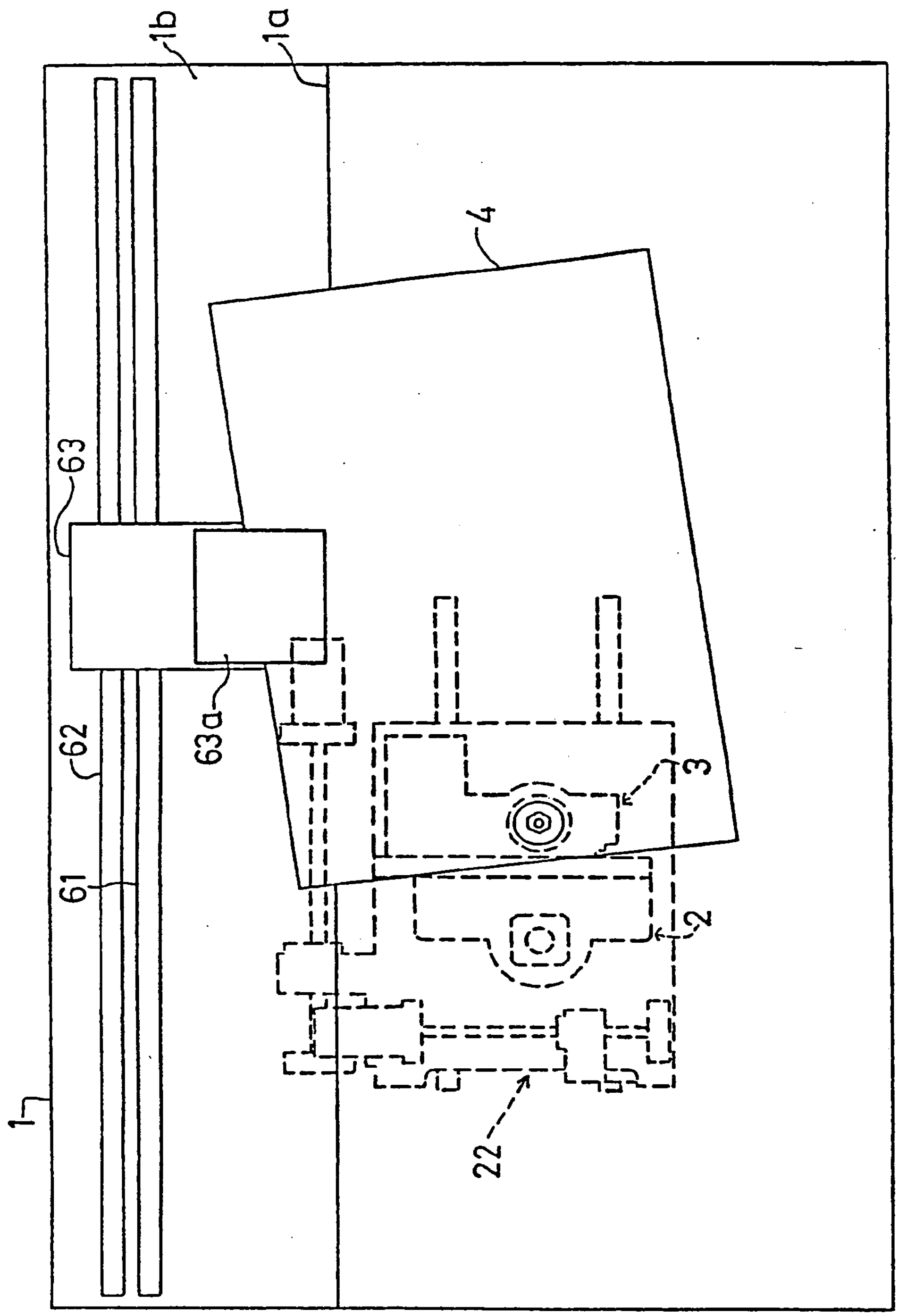


FIG.8

FIG. 9

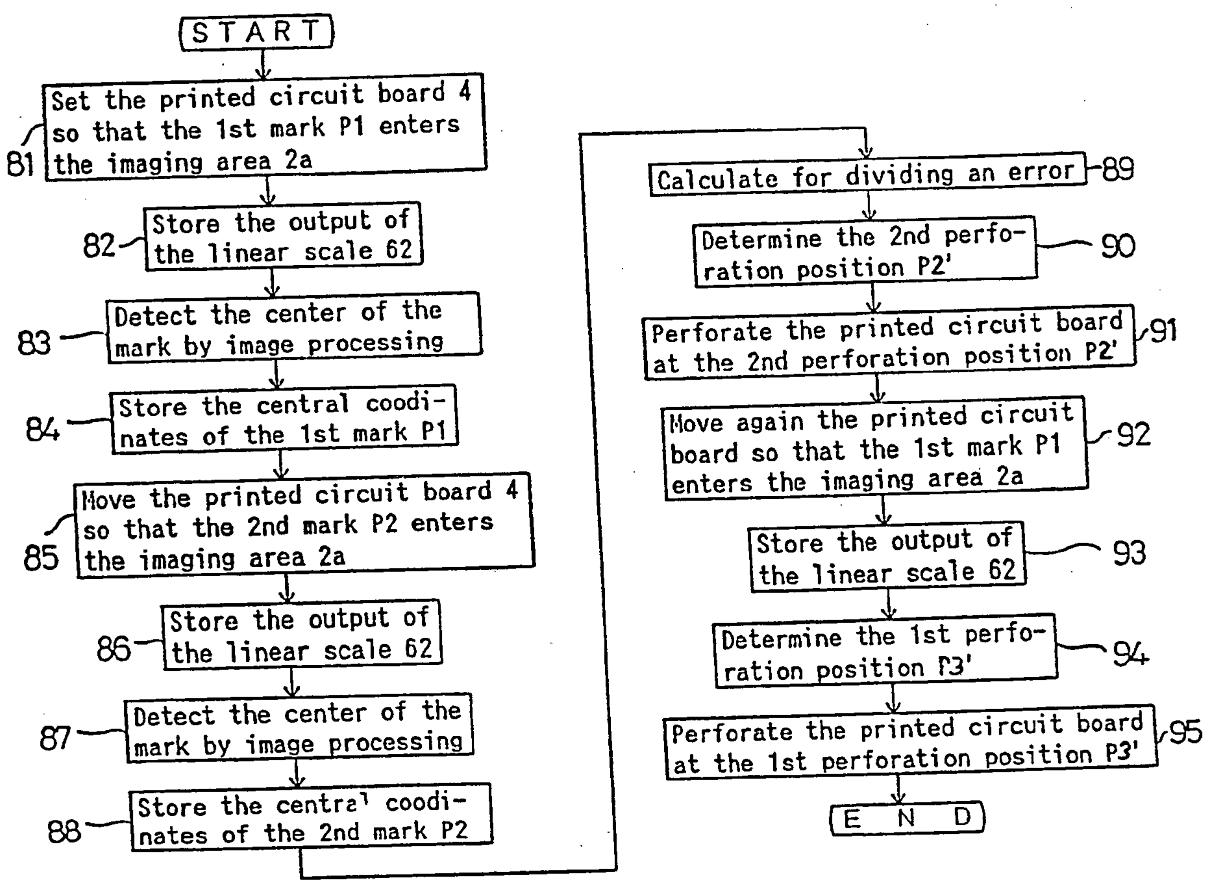

START
Set the printed circuit board 4 so that the 1st mark P1 enters the imaging area 2a
81
Store the output of the linear scale 62
82
Detect the center of the mark by image processing
83
Store the central coodinates of the 1st mark P1
84
Move the printed circuit board 4 so that the 2nd mark P2 enters the imaging area 2a
85
Store the output of the linear scale 62
86
Detect the center of the mark by image processing
87
Store the central coodinates of the 2nd mark P2
88
Calculate for dividing an error
89
Determine the 2nd perforation position P2'
90
Perforate the printed circuit board at the 2nd perforation position P2'
91
Move again the printed circuit board so that the 1st mark P1 enters the imaging area 2a
92
Store the output of the linear scale 62
93
Determine the 1st perforation position P3'
94
Perforate the printed circuit board at the 1st perforation position P3'
95
END

FIG.10

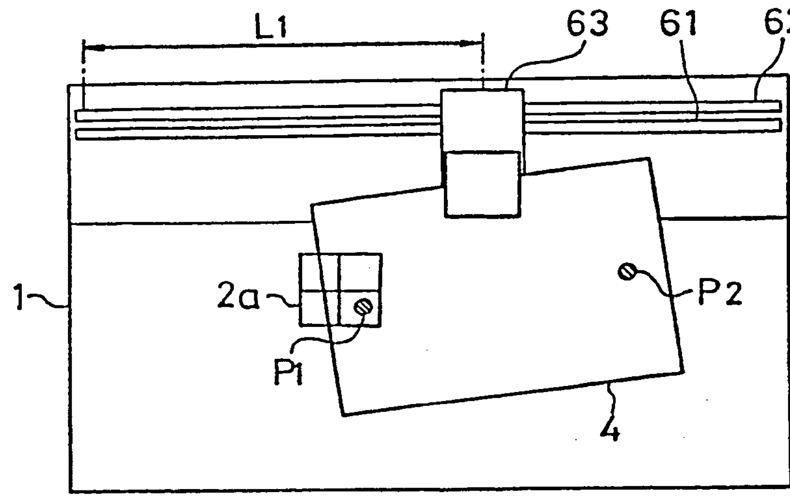


FIG.11

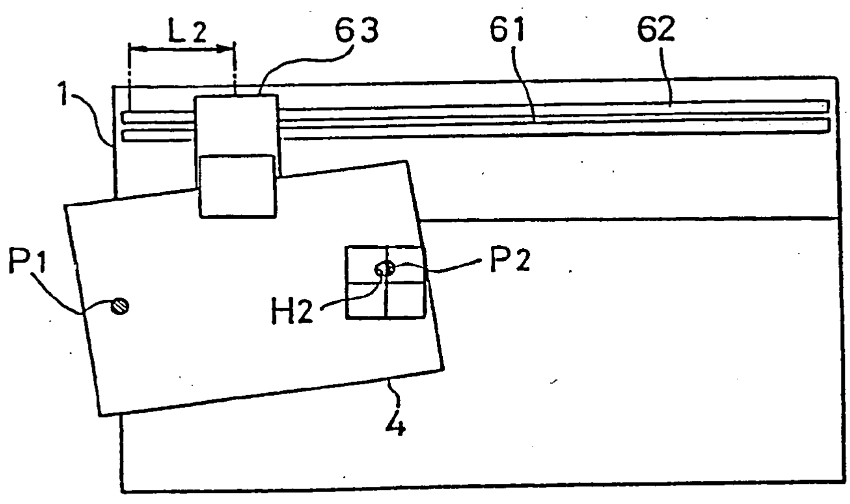


FIG.12

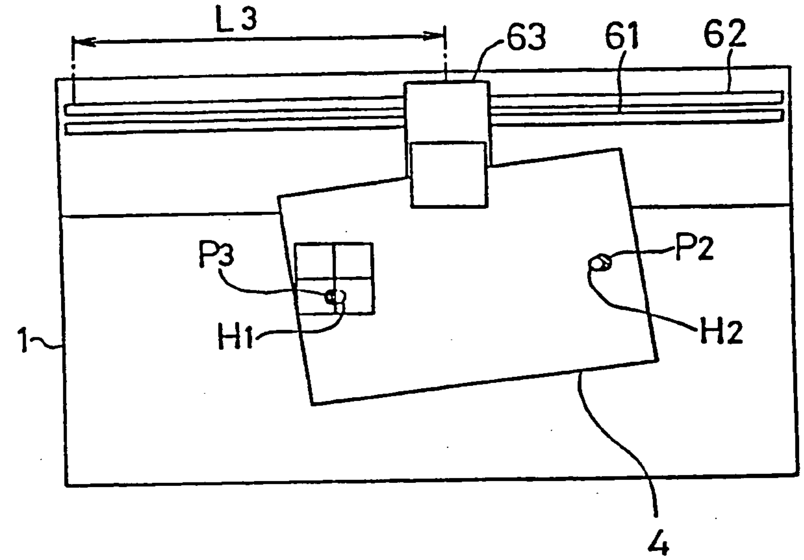


FIG.14

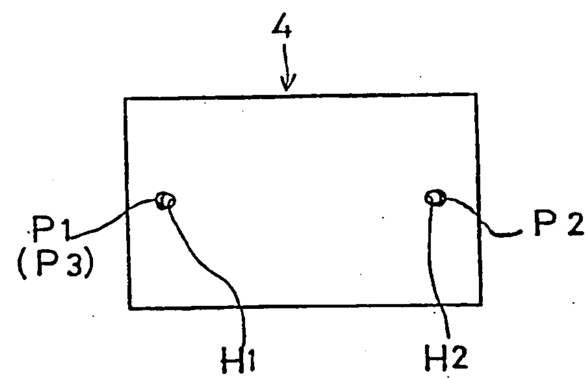
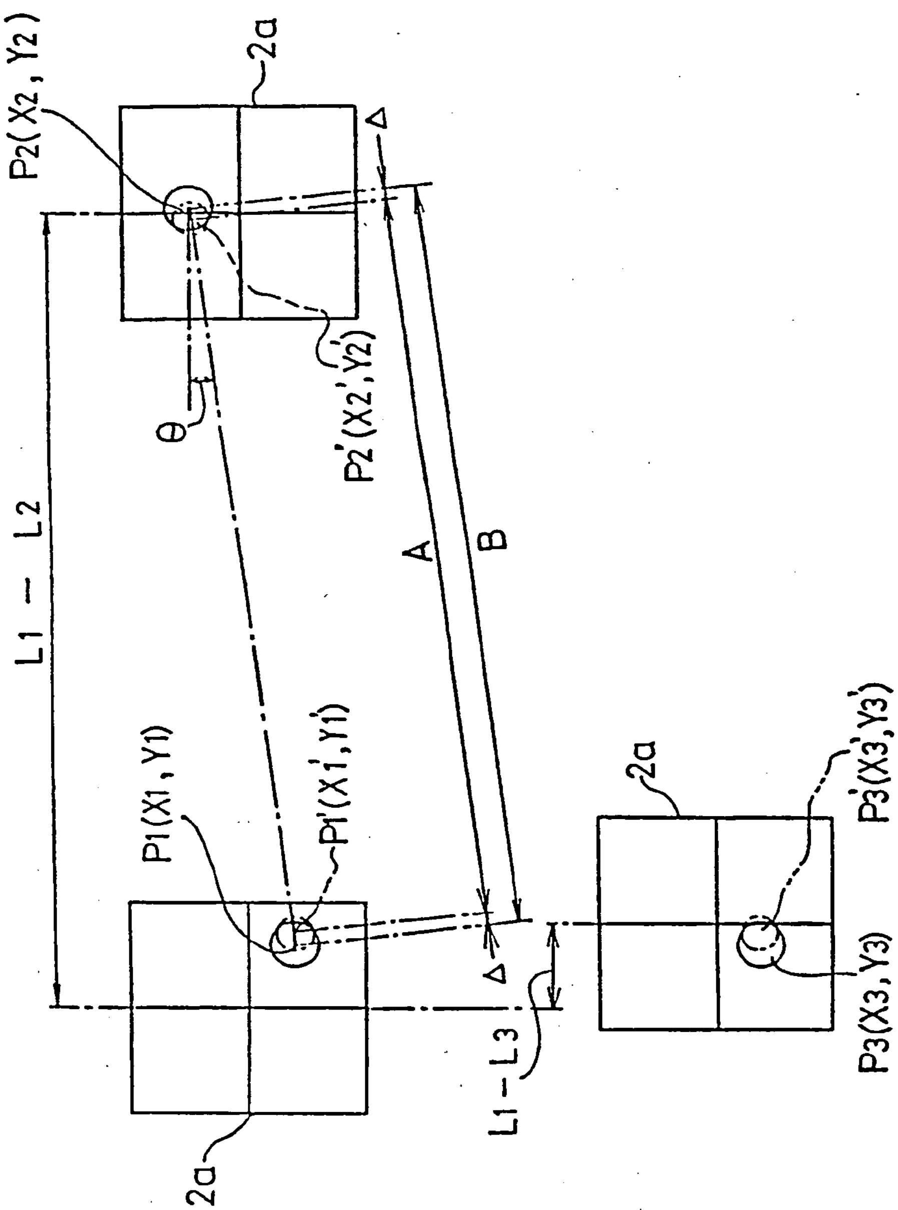


FIG.13


P2(X2, Y2)
2a
Δ
P2'(X2', Y2')
θ
L1 — L2
A
B
P1(X1, Y1)
P1'(X1', Y1')
2a
P3'(X3', Y3')
Δ
L1 — L3
P3(X3, Y3)
2a

2288229

METHOD AND APPARATUS FOR PERFORATING PRINTED CIRCUIT BOARDS

The present invention relates to a method and an apparatus for perforating a printed circuit board.

Heretofore, in the manufacture of printed circuit boards, a method has been used which comprises printing a plurality of circuit patterns on one large size board and subsequently obtaining a plurality of circuit boards by cutting and separating the board for each of the circuit patterns. In

the process of cutting the circuit board, guide holes are formed on the board which holes accommodate guide pins provided on a processing apparatus for subsequently cutting the board. Consequently, the guide holes constitute a basis for determining the cutting position. Thus, guide hole perforation at accurate positions is demanded. For example, when guide pins are to enter a plurality of guide holes, the guide holes cannot be entered by the guide pins unless the spaces between the guide holes are accurate.

As one of such apparatus for perforating a printed circuit board to which marks preliminarily attach on positions to be perforated in the process of printing a circuit pattern, obtains an image of the mark with an imaging means such as a TV camera or an X-ray camera provided on the apparatus for perforating the printed circuit board, and processes the image so that a perforating means is moved to a position obtained as a result of image processing for perforating the printed circuit board.

Perforating in one type of such an apparatus is performed as follows. In providing perforations, for example, perforations on either side of the printed circuit board, the central position of one of the reference marks is firstly detected and subsequently the central position of the

other reference mark is detected to obtain the distance between the two reference marks. The difference between the obtained distance and the predetermined distance between the perforations inputted into the central processing unit (CPU) is divided into halves, each of which is equally shared between the detected central positions of the reference marks for setting corrected positions for the perforation. This is followed by accurately moving the perforating means to the corrected positions and performing perforation.

[~~0005~~]

Further, as another method for perforating the printed circuit board, for improving the efficiency of perforation, a method is also adopted which includes providing two units each comprising an imaging camera, an XY table and a perforating means, in which one of the two such units is fixed to be a reference for moving the other units to the aforementioned corrected position for perforating the printed circuit board (Japanese Patent laid-open No. 91-277411).

However, the aforementioned prior art has the following problems. At the outset, the former method has a drawback of high cost because the method requires a large and highly accurate XY table for moving the perforating means accurately

to the perforation positions respectively. On the other hand, the latter method has also a drawback of a high cost because the method uses two units. In particular, a method using an X-ray camera as the imaging means requires much cost.

Therefore, the present invention seeks to provide a method and an apparatus which is capable of accurately perforating a printed circuit board in a simple manner without requiring a lager XY table.

According to one aspect of the present invention there is provided a method of perforating a printed circuit board according to at least two reference marks on the board, the method comprising the steps of:

holding the printed circuit board with movable holding means;

moving the board holding means to a first position so that a first of the reference marks lies in an imaging area of imaging means and determining position data for said first reference mark in the image area using the imaging means;

moving the board holding means to a second position, so that a second reference mark lies in the imaging area of said imaging means, measuring the distance moved by said holding means between the first and second positions;

determining position data for said second reference mark in the image area using the imaging means;

using the determined position data of the first and second reference marks and said distance moved to calculate the relative positions of the reference marks;

comparing the calculated relative positions with desired reference mark position data to determine any error difference between the calculated and desired position data; and

sharing the error difference between the two reference marks positions to provide corrected values for the positional data for perforation position relative to each of the reference marks.

According to a second aspect of the present invention there is provided a method for perforating a printed circuit board according to the present invention comprises the steps of: chucking with a chuck member the printed circuit board on which at least a pair of reference marks are formed, and setting the printed circuit board so that the first one of the pair of reference marks enters an imaging area of an imaging means; obtaining an image of the first reference mark with the imaging means; detecting the position of the first reference mark on the basis of position data of the chucking member and an image processing result obtained by the imaging means, the position data being obtained by the detecting means for moving distance which means is interlocked with the chuck

member; subsequently moving the printed circuit board by moving the chuck member to set the printed circuit board so that the second one of the pair of reference marks enters the imaging area of the imaging means: obtaining an image of the second reference mark with the imaging means; detecting the position of the second reference mark on the basis of the position data of the chuck member and the image processing result obtained by the imaging means, the position data being obtained by the detecting means for moving distance; comparing position data of the first and second reference marks with position data of desired perforation preliminarily stored in a memory circuit, and dividing an error between the position data into two, to set a first correction value for correcting the position of the first reference mark and a second correction value for correcting the position of said second reference mark thereby calculating a second perforation position on the basis of this second correction value; perforating the printed circuit board at said second perforation position by using perforating means; moving the printed circuit board by moving the chuck member to set again the printed circuit board so that the first reference mark enters the imaging area of the imaging means; calculating a first perforation position by correcting the position of the first reference mark by the first correction value on the basis of the position data of the chuck member and the

position data of the first and second reference mark, the position data of the chuck member being obtained by the detecting means for moving distance, and perforating the printed circuit board at the first perforation position by using the perforating means.

The first and the second correction values may be set to a half value of an error between the two correction values. According to a third aspect of the invention an apparatus for
perforating a printed circuit board for applying a method for perforating the printed circuit board comprises: a work table on which the printed circuit board is placed, the printed circuit board having at least a pair of reference marks provided thereon; an imaging means for obtaining an image of the pair of reference marks; an image processor for processing an image obtained by the imaging means; a central processing unit to which data is input from the image processor; and single perforating means being controlled by the central processing unit for perforating the printed circuit board; the work table providing a chuck member being movable on the work table with the printed circuit board chucked and a detecting means for moving distance for outputting position data of the chucking member to the central processing unit; and the central processing unit providing a memory circuit for storing data output from the

detecting means for moving distance and the image processor, and an arithmetic circuit for determining positions of both reference marks from data output from the detecting means for moving distance and the result of said image processing, and calculating a perforation position in which position error of said reference mark is corrected on the basis of the position data of a predetermined perforation preliminary stored in the memory circuit.

For a better understanding of the present invention reference will now be made by way of example to the accompanying drawings, in which:-

Fig. 1 is a block diagram showing a perforation apparatus of the present invention.

Fig. 2 is a right side sectional view showing an essential portion of the construction of an embodiment of the present invention.

Fig. 3 is a sectional view taken along line A-A of Fig. 2.

Fig. 4 is a sectional plan view taken along line B-B of Fig. 3.

Fig. 5 is a plan view of moving means.

Fig. 6 is a left side view of the moving means.

Fig. 7 is a sectional view taken along line C-C of Fig. 5.

Fig. 8 is a plan view showing a state in which a printed circuit board is placed on a work table with a holding or chuck member.

Fig. 9 is a flowchart showing a method of perforation according to the present invention.

Fig. 10 is a plan view showing a state in which a first reference mark is positioned in the imaging area of imaging means.

Fig. 11 is a plan view showing a state in which perforation has been performed by positioning a second reference mark in the imaging area of the imaging

means.

Fig. 12 is a plan view showing a state in which perforation has been performed by locating a first perforation position in the imaging area of the imaging means after the printed circuit board is perforated at the second perforation position.

Fig. 13 is an explanatory view for illustrating a positional relationship which constitutes the basis of calculation of determining perforation position.

Fig. 14 is a plan view showing a state in which a printed circuit board is perforated at a position obtained by correcting the position of a reference mark of the printed circuit board.

One embodiment of the present invention is explained with reference to the drawings. Figs. 2 and 3 show an entire structure of an apparatus for perforating a printed circuit board according to the present invention. Under a work table 1, an imaging means 2 for obtaining a transmitted image through a work applied X-ray radiation and a perforating means 3 are provided. On the table 1, a printed circuit board 4 as a work is placed so that it can be fed. As the imaging means 2 an II (Image Intensifier) type X-ray camera is adopted, which has a high photosensitivity under a small quantity of X-ray radiation. This type of camera has an advantage of having a much longer life as well as being more economical than a PbO (lead oxide) type vidicon type X-ray camera used in the prior art.

A support member 5 is provided at a certain distance above the table 1. On this support member 5, an X-ray irradiating means 6 is supported. On the lower surface of the support member 5, a protective cover 7 is fixed. Inside of the protective cover 7, a path for the X-ray and a preventing means to prevent leakage of the X-ray are provided.

To this X-ray irradiating means 6, a protecting pipe 8 is connected which constitutes the path 8a of X-ray. On the protecting pipe 8, a shutter 9 is provided so that the shutter 9 traverses the path 8a of X-ray. A shutter cylinder 10 drives and moves the shutter 9 in the forward and backward directions to open and close the path 8a of the X-ray. On the external periphery of the protecting pipe 8a guide groove 8b is formed which runs in the vertical direction. Furthermore, a metal piece 8d of lead or the like is embedded to increase the effect of preventing the X-ray leakage.

Below the protecting pipe 8, a protecting cylinder 11 having a path 11a of X-ray which communicates to the path 8a is provided so that the cylinder 11 is both approachable to and withdrawable from the printed circuit board 4. This protecting cylinder 11 serves as a clamper for pressing this printed circuit board 4 onto the surface of the work table 1

and is fixed to the lower end of the cylindrical member 12 which is fitted to the external periphery of the protecting pipe 8. On part of the cylindrical member 12, a plate 13 is integrally provided which has inside thereof a guide 13a that is slidable within the groove 8b. Below the support member 5, a cylinder 14 is provided as means for lowering a protecting pipe 11 in parallel with the cylindrical member 12. The cylinder 14 lowers the protecting pipe 11 by means of a connecting member 15 which is fixed to the cylindrical member 12 and transmits the extension of the cylinder rod 14a to the cylinder body 12. The protecting pipe 11 is provided with a brake means not shown and can be stopped at an arbitary position by a controlling means. The protecting pipe 11 is elevated by means of the cylinder 14. A return spring 16 is hooked to the connecting member 15 so as to prevent the protecting pipe 11 from falling down due to its own weight when the air supply is down.

On both sides of the protecting pipe 8 a sensor support plates 17 is suspended. Inside of the lower end of the sensor support plate 17, a sensor 18 is fixed. The sensor 18 detects whether the printed circuit board 4 is located at a lower position of the paths 8a and 11a. The shutter 9 is opened and closed with the output of the detection signal.

Around the periphery of the X-ray paths 8a and 11a provided below the X-ray irradiating means 6, a shielding member (not shown) is provided as preventing means for preventing the leakage of X-rays. As the shielding member, a synthetic resin sheet as can be seen in the prior art is used which contains lead. Two sheets of shynthetic resin having vertical slits at suitable intervals at a sleeve portion thereof are provided in parallel to each other. In the irradiation of X-ray, the sleeve portion contacts a work on the table. Consequently, the apparatus of the present invention is able to shield the leakage of the X-ray by tightly closing the inside of the sheets.

In the vicinity of a position where such work as imaging and perforation are carried out, a work receiving portion 21 is located between the table 1 and the substrate 4. The work receiving portion 21 is provided with a mirror which reflects the light of the sensor. The sensor can detect the presence of the printed circuit board 4 when the printed circuit board 4 shields the light.

Next, an XY table mechanism (moving means) 22 is explained hereinbelow. The XY table mechanism moves the imaging means 2 and the perforating means 3 located below the table 1 to a work position. As shown in Fig. 4, on the upper

surface of the support plate 23 fixed to the main body of the apparatus (not shown), a pair of rails 24 and 25 are provided in the horizontal direction (X direction). On these rails 24 and 25, sliders 26a, 26b, 26c and 26d are provided which can be slid in the X direction. Further, on the upper surface of these sliders 26a, 26b, 26c and 26d, sliders 27a, 27b, 27c and 27d which are guided in the vertical direction (Y direction) of Fig. 4 are fixed in a state in which the surface fitted to the rail is directed upward. The sliders 26a through 26d and the sliders 27a through 27d are arranged with respective sliding direction being substantially perpendicular to each other. On these sliders 27a through 27d, a pair of rails 28 and 29 are slidably fitted which extend in the Y direction. In addition, a motor 30 is fixed onto the support plate 23, and a lead screw 31 connected to the drive axis of the motor 30 is rotatably arranged. Then, a nut 32 is threaded onto this lead screw 31 The nut 32 is fixed to the sliders 26a and 27a through the nut holder 33. Therefore, when the lead screw 31 is rotated with the drive of the motor 33, the nut 32, the nut holder 33, and the sliders 26a and 27a are moved in the X direction. At this time, since the sliders 26a and 27a are connected with the rail 28, the sliders 26b and 27b are moved together.

A moving table 34 is fixed onto the rail 28 and 29. As

shown in Fig. 5, a motor 35 is fixed onto the moving table 34. The lead screw 36 connected to the drive axis of the motor 35 is rotatably arranged. A nut 37 is threaded onto the lead screw 36. The nut 37 is fixed to the lead screw 36. This nut holder 38 is fixed to the aforementioned sliders 26b and 27b (see Fig. 4). This nut holder 38 is not fixed to the moving table 34. In this structure, when the lead screw is rotated with the drive of the motor 35, the nut 37 will be about to move in the Y direction. However, it cannot be moved in the Y direction since the nut holder 38 is fixed to the sliders 26b and 27b, and the slider 26b is fitted to the rail 25. Consequently, when the lead screw 36 rotates with the drive of the motor 35, the nut 37 does not move, but the motor 35 and the moving table 34 move in the Y direction. Hence, the aforementioned structure of the XY table mechanism 22 enables the moving table 34 to move in the XY direction with the drive of the motors 30 and 35.

This XY table mechanism 22 has an extremely small size since it is for moving the perforating means 3 within the imaging area 2a (see Fig. 10).

The imaging means 2 and the perforating means 3 will now be explained by referring to Figs. 2, 3 and 6. On the moving table 34, the support plate 39 is erected. On

the support plate 39, an X-ray camera 2 is held which serves as an imaging means via a connecting plate 40 and the cylinder member 41. To the X-ray camera an image processor and a central processing unit are connected. On the basis of the result of image processing of a transmitted image of work, the movement of the aforementioned XY table mechanism 22 or the like is controlled.

On the opposite side of the support plate 39, a pair of rails 42 and 43 are provided. A rail guide 44a is provided on a holding frame 44 for holding a perforating means 3 which serves as a processing means. This guide rail 44a is slidably engaged with the pair of rails 42 and 43. The perforating means 3 comprises a spindle motor 3a, a collect chuck 3b fixed to the upper end of the motor 3a, and a drill 3c held on the collect chuck 3b. The drill 3c is rotated with the drive of the spindle motor 3a to perform the perforating of the printed circuit board 4. At the upper end of the perforating means 3, a chip cover 45 is attached.

Next, a driving mechanism 46 for driving the perforating means in the vertical direction (Z direction) will be explained hereinbelow by referring to Fig. 7. Incidentally, Fig. 7 is a sectional view taken along line C-C of Fig. 5 for the clarification of the construction thereof. On the

support plate 39, a lead screw 48 is rotatably attached which extends in the Z direction. This lead screw 48 is threaded onto the nut 49. Further, this nut is fixed to the aforementioned holding frame 44 via a nut holder 50. The upper end of the lead screw 48 is connected to the belt pulley 51. In addition, a motor 52 is held on the attachment member 47. The driving axis of the motor 52 is connected to the belt pulley 53. The belt pulley 51 and 53 carry a belt 54. Consequently, when the belt pulley 53 rotates with the drive of the motor 52, the rotation of the belt pulley 53 is transmitted to the belt pulley 51, whereby the lead screw 53 rotates. Then the nut holder 50 and the holding frame 44 moves in the Z direction integrally with the nut 49, whereby the perforating means 3 held in the holding frame moves in the upward and downward direction.

On the lower surface of the support member 5 located above the work table 1, a laser marker (not shown) is provided together with the protecting cover 7. The laser marker is able to provide on the work table a straight line mark with an extremely small line width formed by a laser beam.

Next to this, will be explained the holding means or chuck member and the linear scale as an example of the detecting means for determining the moving

distance of the holding means. As shown in Fig. 8, on the upper surface of the work table 1 a step 1a is provided by lowering the upper portion shown in Fig. 8. On this lowered surface 1b, a linear guide 61 and a linear scale 62 are provided. On the linear guide 61, a chuck member or holding means 63 is provided so that it is movable along the linear guide 61. The chuck member 63 chucks the printed circuit board 4 to transfer the printed circuit board 4 on the work table 1. In this embodiment, the chuck member has a structure for being moved manually without providing any driving means such as a motor for the purpose of the cost reduction.

The linear scale 62 is provided for outputting a position data of the chuck member 63 by means of a slider (not shown) connected to the chuck member 63.

For this purpose the slider has a detecting head in which a detector such as a magnetic resistance thin film element is provided. In this embodiment an MR magnescale (trademark: manufactured by Sony Magnescale Co., Ltd.) is adopted. On the end of the chuck member 63, a clamp 63a is provided which grips the printed circuit board 4.

With reference to a block diagram shown in Fig. 1, a control means in this particular embodiment will be explained. A central processing unit (CPU) obviously constitutes a core of the control means and a perforating

means 3, an X-ray irradiating means 6 and an XY table mechanism 22 are controllably connected to the CPU 64. The X-ray irradiating means 6 is provided in such a manner that the X-ray irradiation transmits the work so that the transmitted image of the mark attached on this work can be obtained with an X-ray camera 2. An image processor 65 is connected to the X-ray camera so that it processes the image data from the X-ray camera 2 and is connected to the CPU 64 so that the image data can be outputted to the CPU 64. In addition, a linear scale 62 which constitutes the detecting means for moving distance of the chuck member 63, a memory circuit 66 and an arithmetic circuit 67 are connected to the CPU 64. The linear scale 62 can output position data of the chuck member 63. The position data and the image data from the image processor 65 can be stored in the memory circuit 66. The arithmetic circuit 67 performs a calculation for determining the perforation position in accordance with an instruction from the CPU 64 by using position data from the linear scale, the result of image processing and preliminarily set data or the like. The result of the calculation can be supplied as an output to the CPU 64. Furthermore, a TV monitor (not shown) is connected to the CPU 64.

A procedure of perforating the printed circuit board 4 at a predetermined position in the present invention will be

explained in accordance with a flowchart shown in Fig. 9.

In this particular embodiment, the printed circuit board which is to be perforated is a multilayer board having unexposed circuit pattern and reference marks for perforation formed on the inner layer. The reference marks are provided symmetrically on both right and left sides of the printed circuit board. Let the left side mark be a reference mark P1 whereas let the right side mark be a second reference mark P2 (see Figs. 10-12). Prior to the perforation work, the position of the second reference mark P2 is roughly located from the appearance of the surface of the printed circuit board 4 at which a temporary mark is attached with an oil-based pen.

The process of setting the printed circuit board 4 on the work table 1 comprises at the outset allowing the printed circuit board to be held or checked with the holding means or chuck member 63 on the work table 1 (see Fig. 9). Subsequently, chucking the printed circuit board is adjusted so that the previously attached temporary mark comes on the line that is set by the laser marker. The chuck member is then manually moved with the chucked printed circuit board monitored by the X-ray camera 2 to set the printed circuit board at a position where the reference mark P1 enters the imaging area 2a of the X-ray camera 2 (see Fig. 10). (81).

Subsequently, the image of the first reference mark P1 is obtained with the X-ray camera 2 and, at the same time the position of the chuck member 63 is detected with the linear scale 62. The position data (L1) is supplied to the CPU 64 and stored in the memory circuit 66 (82). At this time, the image processor 65 processes the obtained image and the resulting data of the image processing is used for determining the position of the first reference mark P1 together with the position data of the linear scale (83). The coordinates (X1, Y1) at the central position of the first reference mark P1 are stored in the memory circuit 66 (84). In following explanations, the coordinates are shown with their origin being at the center of the imaging area 2a.

Then the chuck member 63 is manually moved to set the printed circuit board so that the reference mark P2 enters the imaging area 2a of the X-ray camera 2 (see Fig. 11). At this time, the position data L2 of the linear scale 62 is also stored in the memory circuit 66 (86).

Here, the image of the second reference mark P2 is obtained with the X-ray camera 2 and the obtained image is also processed with the image processor 65 to determine the central position of the second reference mark (87). The coordinates (X2, Y2) at the center of the second reference mark P2 are stored in the memory circuit 66 (88).

Subsequently, the distance B between both central positions of the first and second reference marks, that is the distance obtained from coordinate (X1, Y1) at the central position of P1, the coordinate (X2, Y2) at the central position of P2, and the position data L1 and L2 of the linear scale 62, are compared with the predetermined distance A between perforations which has been preliminarily stored in the memory circuit 66 to calculate an error (B-A) between the two distances. The calculation will be explained in detail. At the outset, as illustrated in Fig. 13, an inclination angle θ of the printed circuit board 4 relative to the linear scale 62 is determined from the following equation.

[Equation 1]

$$\theta=\tan^{-1}\{(-Y1+Y2)/[(L1-L2)+(X2-X1)]\}$$

Further, the distance B between the central positions of the reference marks is determined in the following equation.

[Equation 2]

$$B=\sqrt{(L1-L2+X2-X1)^2 + (Y2-Y1)^2}$$

In this embodiment, the perforation positions are determined to be the positions P1' and P2' which are obtained

as being corrected from the positions of the first and second reference marks by sharing the error between the aforementioned B and A by the half value. Namely, the shared correcting value Δ is represented by the following equation.

$$\Delta=(B-A)/2$$

This corresponds to the first or the second correction value.

From the Δ and θ determined by the aforementioned equations and the coordinates at the central positions of the reference marks P1 and P2, the perforation positions are obtained from the following equations.

Namely, the coordinates (X2', Y2') of the second perforation position P2' are calculated out by the following equations (90).

$$X2' = X2 - \Delta\cos\theta$$

$$Y2' = Y2 - \Delta\sin\theta$$

When the second perforation position is determined, the central processing unit 64 supplies an output signal for positioning to the drive motor of XY table mechanism 64. Here, perforating means 3 is faced to the second perforation position P2'. And by an output signal also supplied from the CPU 64, H2 is perforated at the second perforation position (91).

Subsequently, the chuck member 63 is manually moved to

set the printed circuit board 4 at the position where the first reference mark P1 again enters the imaging area 2a of the X-ray camera 2 (92). The position may be somewhat different from the initial position of the board 4 (in the step 81), but should be in its vicinity. The position of the chuck member 63 at this time is read with the linear scale 62 to be stored as the position data L3 in the memory circuit 66 (93). The arithmetic circuit 67 performs calculation on the basis of these data to determine the first perforation position P3' (94). At this time, the image of the first reference mark does not need to be obtained again.

If we let the central position of the reference mark be positioned at (X3, Y3), the coordinates (X3', Y3') of the first perforation position P3' are determined from the following equations.

$$X3' = X3 + \Delta\cos\theta = X1 - (L1 - L3) + \Delta\cos\theta$$

$$Y3' = Y3 + \Delta\sin\theta = Y1 + \Delta\sin\theta$$

This calculation is based on the fact that the chuck member 63 is transferred in the X-axis direction along the linear guide 62, and the equation of X3=X1-(L1-L3) and Y3=Y1 are established. Incidentally, the perforation at the corrected position can be performed without determining P1' (X1', Y1') and P3 (X3, Y3) which are indicated in Fig. 13.

Here the XY table mechanism 22 is operated again to perforate the first perforation H1 at the first perforation position P3′ (X3′, Y3′) determined on the printed circuit board 4 with the perforating means 3 (95). Thus, in the printed circuit board 4 perforations H1 and H2 are provided at positions P2', P3' with the correction of sharing the error by Δ between both reference marks.

In this embodiment, the printed circuit board to be perforated is a multilayer board , for which, an X-ray camera is adopted as an imaging means to obtain images of reference marks that are not exposed to the surface. However, a normal TV camera may be satisfactory only for perforating the printed circuit board having an exposed positioning marks instead of the multilayer substrate. The apparatus incorporating the normal camera is advantageous in its cost since it does not require an expensive X-ray generating apparatus and a danger protecting means.

As a perforating means, a drill is adopted, which can be replaced with other means such as a punch or the like. Incidentally, by allowing the movement direction of the chuck member, which is set only in the X direction in the afore-mentioned embodiment, to be in the XY direction, the positioning of three disposed points can be made possible in addition to that of two points.

In this embodiment, the printed circuit board is perforated with the first and the second correction values made equal between which an error in distance between the two reference marks are halved for being shared. When one of the two reference marks should be more weighted than the counterpart of the other, the first correction value may be set, for example, to 0 with the second correction value set to 2Δ, and the reverse is also possible. In this manner, the method for determining the first and the second correction values by sharing the error is not restricted to the aforementioned method of equally dividing, but various dividing method can be applied thereto.

The XY table mechanism 22 used in the present invention is a small-sized one for moving the perforating means 3 within an extremely fine region in the imaging area 2a. The mechanism 22 is therefore far less expensive compared with a conventionally used large XY table which moves the perforating means 3 from one end of the printed circuit board 4 to the other end.

According to the present invention, there is provided an apparatus for perforating a printed circuit board comprising

a single perforating unit including a perforating means and a positioning means, which apparatus readily enables perforation at exact position with a low cost detecting means for moving distance without providing a large-sized XY table, which contributes to the manufacturing cost reduction of the printed circuit boards.

Further, the apparatus of the present invention stores the coordinates at the central positions of the reference marks and the position data of the chuck member detected by the linear scale in the memory circuit, obtains an error between predetermined positions for perforation and central positions of the reference marks calculated out by an arithmetic circuit, and shares the error between the data of the central positions of the reference marks to determine the corrected positions for perforation where the perforation is performed. Consequently, the printed circuit board can be perforated at the exact positions and the quality of the printed circuit board can be improved.

The apparatus of the present invention is able to provide perforations at exact positions on the printed circuit board with a single perforating means. Thus, the present invention does not require a highly expensive NC apparatus, a large-sized XY table or a plurality of highly

expensive X-ray camera so that the manufacturing cost of the apparatus for perforating a printed circuit board can be reduced.

CLAIMS

1. A method of perforating a printed circuit board according to at least two reference marks on the board, the method comprising the steps of:

holding the printed circuit board with movable holding means;

moving the board holding means to a first position so that a first of the reference marks lies in an imaging area of imaging means and determining position data for said first reference mark in the image area using the imaging means;

moving the board holding means to a second position, so that a second reference mark lies in the imaging area of said imaging means, measuring the distance moved by said holding means between the first and second positions;

determining position data for said second reference mark in the image area using the imaging means;

using the determined position data of the first and second reference marks and said distance moved to calculate the relative positions of the reference marks;

comparing the calculated relative positions with desired reference mark position data to determine any error difference between the calculated and desired position data; and

sharing the error difference between the two reference marks positions to provide corrected values for the positional data for perforation position relative to each of the reference marks.

2. A method according to claim 1 wherein said calculation is carried out with the holding means at said second position;

wherein said board is then perforated at the corrected value position related to the second

reference mark;

wherein the board holding means is then moved such that said first reference mark enters the imaging area of the imaging means;

the position for the calculated corrected value perforation relative to the first perforation is determined from said calculation and the movement of said holding means; and

said board is perforated at this corrected value position.

3. A method of perforating a printed circuit board in association with at least two reference marks on the board, comprising the steps of:

chucking with a chuck member the printed circuit board, and setting said printed circuit board so that the first one of the pair of reference marks enters an imaging area of an imaging means;

obtaining an image of said first reference mark with said imaging means;

detecting a position of said first reference mark on the basis of position data of said chucking member and an image processing result obtained by said imaging means, said position data being obtained by detecting means for moving distance which is interlocked with said chuck member;

subsequently moving said printed circuit board by moving said chuck member to set said printed circuit board so that said second one of said pair of reference mark enters said imaging area of said imaging means;

obtaining an image of said second reference mark with said imaging means;

detecting a position of said second reference mark on the basis of the position data of said chuck member and the image processing result obtained by said imaging means, said position data being obtained by said detecting means for moving distance;

comparing position data of said first and second reference marks with position data of desired perforation preliminarily stored in a memory circuit, and dividing an error between the position data so as to be shared between said position data of said first and second reference marks, to set a first correction value for correcting the position of said first reference mark and a second correction value for correcting the position of said second reference mark thereby calculating a second perforation position on the basis of this second correction value;

perforating said printed circuit board at said second perforation position by using perforating means;

moving said printed circuit board at said second perforation position by using perforating means;

moving said printed circuit board by moving said chuck member to set again said printed circuit board so that said first reference mark enters said imaging area of said imaging means;

calculating a first perforation position by correcting the position of said first reference mark by said first correction value on the basis of the position data of said chuck member and the position data of said first and second reference mark, said position data of said chuck member being obtained by said detecting means for moving distance; and

perforating the printed circuit board at said first perforation position by using said perforating means.

4. A method for perforating the printed circuit board according to claim 1 wherein said first and second correction values are equal to a half of said error.

5. An apparatus for perforating a printed circuit board comprising:

a work table on which the printed circuit board is

placed, said printed circuit board having at least a pair of reference marks provided thereon;

imaging means for obtaining any image of said pair of reference marks;

an image processor for processing an image obtained by said imaging means;

a central processing unit to which data is input from said image processor; and

single perforating means which is controlled by said central processing unit for perforating said printed circuit board;

said work table providing a chuck member being movable on said work table with said printed circuit board chucked and a detecting means for moving distance for outputting position data of said chucking member to said central processing unit; and

said central processing unit providing a memory circuit for storing data output from said detecting means for moving distance and said image processor, and an arithmetic circuit for determining positions of said both reference marks from data output from said detecting means for moving distance and a result of said image processing, and calculating a perforation position in which position errors of said reference marks are corrected on the basis of said position data of a predetermined perforation preliminarily stored in said memory circuit.

6. A method of perforating a printed circuit board substantially as hereinbefore described with reference to the accompanying drawings.

7. Apparatus for perforating a printed circuit board substantially as hereinbefore described with reference to the accompanying drawings.

Patents Act 1977 Examiner's report to the Comptroller under Section 17 -32- (The Search report)	Application number GB 9506639.5
Relevant Technical Fields (i) UK Cl (Ed.N) G1A (AAJL, AAJP) (ii) Int Cl (Ed.6) H05K - 3/00	Search Examiner P S DERRY Date of completion of Search 29 JUNE 1995
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE: WPI	Documents considered relevant following a search in respect of Claims :- 1-4

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A	GB 2243214 A (SEIKOSHA) see abstract	

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